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Occupational exposures and chronic obstructive pulmonary disease (COPD): comparison of a COPD-specific job exposure matrix and expert-evaluated occupational exposures

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Abstract

Objectives—To compare the occupational exposure levels assigned by our National Institute for Occupational Safety and Health chronic obstructive pulmonary disease-specific job exposure matrix (NIOSH COPD JEM) and by expert evaluation of detailed occupational information for various jobs held by members of an integrated health plan in the Northwest USA.

Methods—We analysed data from a prior study examining COPD and occupational exposures. Jobs were assigned exposure levels using 2 methods: (1) the COPD JEM and (2) expert evaluation. Agreement (Cohen's κ coefficients), sensitivity and specificity were calculated to compare exposure levels assigned by the 2 methods for 8 exposure categories.

Results—κ indicated slight to moderate agreement (0.19–0.51) between the 2 methods and was highest for organic dust and overall exposure. Sensitivity of the matrix ranged from 33.9% to 68.5% and was highest for sensitisers, diesel exhaust and overall exposure. Specificity ranged from 74.7% to 97.1% and was highest for fumes, organic dust and mineral dust.

Conclusions—This COPD JEM was compared with exposures assigned by experts and offers a generalisable approach to assigning occupational exposure.

INTRODUCTION

Occupational exposure to vapours, gases, dusts or fumes is associated with the development of chronic obstructive pulmonary disease (COPD).[1] Epidemiological studies of COPD use a variety of methods to assign estimates of occupational exposure levels.[1–3] These methods

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include a National Institute for Occupational Safety and Health COPD-specific job exposure matrix (NIOSH COPD JEM) previously constructed by three NIOSH industrial hygienists (IHs).[23] The NIOSH COPD JEM was developed to be a generalisable tool to assess COPD risk by assigning exposure levels to all US Census 2000 Occupations regardless of disease status. Validation of this JEM against other exposure assessment methods is important and may lead to refinement of the tool. In earlier work, we found that occupational dust exposures ascertained by this JEM were associated with spirometry-defined COPD.[2] This study further examined the usefulness of the COPD JEM by comparing COPD JEM-assigned occupational exposures with those assigned by expert evaluation of detailed, occupation, industry and job task information for a variety of jobs held by members of an integrated health plan in the Northwest USA.

METHODS

Data for the present analysis came from a case–control study examining COPD and occupational exposures among members of Kaiser Permanente Northwest (KPNW), an integrated health plan based in Portland, Oregon, USA.[4] KPNW members who were at least 45 years of age, were continuously eligible for healthcare from January 2000 to December 2002 and had worked at least 5 years were randomly selected from the plan's electronic medical records.[4] The original case–control study protocol and protocol for this study were approved by the participating institutions' human participants committees. The cases included 388 participants with COPD and 356 controls matched to cases based on age, sex and cigarette smoking status as documented by medical records.[4] Those with asthma diagnosis during the study period were excluded, but history of asthma was not an indication for exclusion.[4] The mean ages of cases and controls were 67 and 66 years, respectively; 44% of cases and 41% of controls were men. Additional information on participant demographic characteristics and job categories is reported elsewhere.[34] Participants were primarily employed by various industries in Northwest Oregon and Southwest Washington or were retired. Through telephone interviews, participants provided detailed work history for up to eight longest held jobs (held for ≥6 months). IHs assigned US Census 2000 occupation codes to each job.[4]

Assignment of occupational exposure levels

Occupational exposure levels were assigned using two methods. In the original study, two experts (one KPNW IH and one NIOSH IH) independently assigned exposure levels to each job by evaluating detailed, self-reported occupation, industry and job task data, while blinded to the disease status of participants. Reported 'routine' (at least once per week) on-the-job exposure to dust, fumes, smoke, diesel exhaust, gases, or vapours and use of, and exposure to, chemicals (eg, pesticides and compressed gases) were also considered by the experts. Exposure levels ('no/minimal', 'moderate' or 'high', based on exposure severity) for irritant gases or vapours, sensitisers, metal dust and fumes, organic dust, mineral dust, diesel exhaust, combined dust (metal, organic or mineral) and overall exposure (likelihood of exposure to a significant occupational risk) were developed.[34] For the purpose of this paper, 'no/minimal' will be called 'low' and 'moderate' will be called 'medium'. Moderate to high agreement was reported between the two experts' exposure assignments.[4]

Blinded to the experts' exposure assignments and case–control status, we applied the COPD JEM to this data set. US Census 2000 coded occupations were linked to the COPD JEM.[23] For each job, the JEM assigned exposure levels ('low', 'medium' or 'high', based on the likelihood of the presence and severity of exposure) for eight exposure categories linked to the pathway of the development of COPD: vapour–gas, sensitisers, fumes, organic dust, mineral dust, combined dust, diesel exhaust and overall exposure (which considered the above exposures and environmental tobacco smoke).

Data analysis

Statistical analyses were performed using SAS V.9.3 (SAS Institute, Cary, North Carolina, USA). We examined the agreement between the COPD JEM and the expert-assigned exposure levels using Cohen's κ coefficients with corresponding 95% CIs for each dichotomised exposure ('low' vs 'medium/high'). Levels of agreement were defined as <0.00=poor, 0.01 to 0.20=slight, 0.21 to 0.40=fair, 0.41 to 0.60=moderate, 0.61 to 0.80=substantial and 0.81 to 0.99=almost perfect agreement.[5] We calculated sensitivity and specificity with corresponding 95% CIs for each dichotomised exposure using expert assignments as the reference standard. We compared agreement, sensitivity and specificity overall and by COPD status to examine potential information bias. Differences were considered statistically significant if the CIs did not overlap.

RESULTS

The 2737 jobs included 26.8% office, administrative, business, finance, counsellor or legal jobs, primarily assigned 'low' exposure by both exposure methods. The second largest category of jobs included 7.6% sales jobs, also determined to have 'low' exposure. The third largest job category was production-machine operators, helpers or system operators accounting for 6.0% of jobs and over half of these jobs were assigned irritant gases or vapour exposure by the expert method and sensitiser exposure by the COPD JEM.[4] According to the JEM, the two exposure categories with the highest per cent of 'medium/high' exposed jobs were sensitisers (28.4%) and vapour–gas (23.7%). The two exposure categories with the lowest per cent of 'medium/high' exposed jobs were fumes (5.8%) and mineral dust (8.7%). For the overall exposure category, 66.6% of jobs were assigned 'low' exposure (data not shown).

Agreement between comparable exposure categories for the two methods is presented (table 1). κ indicated slight agreement for sensitisers; fair agreement for vapour–gas, mineral dust, combined dust and diesel exhaust; and moderate agreement for fumes, organic dust and overall exposure. The sensitivity of the JEM ranged from 33.9% to 68.5% and was above 60% for sensitisers, diesel exhaust and overall exposure. Specificity ranged from 74.7% to 97.1% and was above 90% for fumes, organic dust and mineral dust. Sensitivity and specificity of the JEM were not statistically different by COPD status.

DISCUSSION

This study compared the occupational exposure levels assigned by the COPD JEM and those assigned when accounting for detailed occupation, industry and job task information for jobs

held by workers in the Northwest USA. We observed moderate agreement between the two methods for the fumes, organic dust and overall exposure categories. The agreement reported in our study was similar to levels published in previous comparisons of JEMs and other occupational exposure assignment methods.[6,7] For example, an asthma-specific JEM had moderate to good agreement with self-reported and investigator assigned occupational exposures.[6]

We hypothesised high sensitivity in this study since one of the experts also helped construct the COPD JEM. However, the sensitivity of the COPD JEM against the expert-assigned levels indicated the JEM method less frequently classified 'medium/high' exposed jobs as exposed. Therefore, this study indicates enhancing sensitivity is important, and we recommend re-evaluating this JEM to further assess its sensitivity. The specificity of the COPD JEM was relatively high, indicating the JEM consistently classified 'low' exposed jobs as 'low' compared with the expert-assigned method.

The exposure categories were generally similar and comparable between the two methods for the sensitisers, organic dust, mineral dust and diesel exhaust categories. However, the COPD JEM vapour–gas category included solvents and differed slightly from the comparison expert-assigned irritant gases or vapours category. The JEM fumes category was compared with the expert-assigned metal dust and fumes category; however, the inclusion of metal dust did not likely affect the agreement because <6% of jobs had 'medium' or 'high' fume exposure. The JEM combined dust category was compared with the expert-assigned combined dust category which also included metal fumes.

This COPD JEM differed from other population COPD JEMs because it was developed to be applicable in the USA with all US Census 2000 Occupations and to assess COPD risk beyond the limited exposure categories of the University of California San Francisco COPD JEM.[8–11] Biological dusts were included in other COPD JEMs, but this JEM evaluated biological dusts through organic dust and sensitisers.[8] The JEM approach is limited because it does not account for exposure variability within the same job across industries. However, applying a previously developed JEM has advantages related to cost and time compared with completing expert evaluation of detailed occupational data or direct occupational exposure assessment.[7] The JEM does not rely on self-reported occupational exposure which may under-represent or over-represent actual exposures and be influenced by a respondent's disease status.[12] We examined the potential limitation of using expert assignments as the reference standard and found differences in agreement, sensitivity and specificity by COPD status were not statistically significant, suggesting low potential for misclassification due to bias.

CONCLUSION

The COPD JEM method of assigning occupational exposures provides a generalisable approach to assign exposure levels in epidemiological studies. While the COPD JEM is a generic method of exposure assignment with limitations related to sensitivity, it showed high specificity compared with exposure levels assigned using detailed job data. The JEM may

have advantages over other exposure classification approaches, including reducing study cost, time and information bias.

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What this paper adds

- The National Institute for Occupational Safety and Health chronic obstructive pulmonary disease-specific job exposure matrix (NIOSH COPD JEM) method of assigning occupational exposures was evaluated for use in epidemiological studies.
- The COPD JEM was consistent with expert evaluation when assigning exposure levels to low exposed jobs.
- Sensitivity of the COPD JEM was highest for sensitisers, diesel exhaust and overall exposure, and specificity was highest for fumes, organic dust and mineral dust.
- COPD JEMs are cost-effective methods of assigning occupational exposures in epidemiological studies.

Table 1

Agreement, sensitivity and specificity of COPD JEM assigned and expert-assigned exposures, overall and by COPD status * (n=2737 jobs)

Exposure category	κ (95% CI)	Sensitivity (95% CI)	Specificity (95% CI)
Vapour–gas †			
All	0.26 (0.22 to 0.30)	44.3% (40.3% to 48.4%)	82.2% (80.5% to 83.8%)
No COPD	0.25 (0.19 to 0.31)	44.4% (38.2% to 50.8%)	82.3% (79.8% to 84.6%)
COPD	0.26 (0.21 to 0.32)	44.2% (39.0% to 49.6%)	82.1% (79.6% to 84.3%)
Sensitisers			
All	0.19 (0.15 to 0.22)	68.5% (61.5% to 74.8%)	74.7% (73.0% to 76.4%)
No COPD	0.22 (0.16 to 0.27)	70.1% (59.8% to 78.8%)	76.9% (74.3% to 79.2%)
COPD	0.16 (0.12 to 0.21)	67.0% (56.9% to 75.8%)	72.8% (70.4% to 75.2%)
Fumes †			
All	0.45 (0.38 to 0.51)	44.2% (37.0% to 51.6%)	97.1% (96.3% to 97.7%)
No COPD	0.38 (0.28 to 0.49)	38.7% (27.9% to 50.7%)	97.1% (96.0% to 98.0%)
COPD	0.49 (0.40 to 0.57)	47.8% (38.4% to 57.4%)	97.0% (95.9% to 97.8%)
Organic dust			
All	0.51 (0.46 to 0.56)	56.3% (50.4% to 62.0%)	94.6% (93.7% to 95.5%)
No COPD	0.55 (0.47 to 0.62)	60.1% (51.4% to 68.3%)	95.1% (93.6% to 96.2%)
COPD	0.47 (0.40 to 0.54)	53.6% (45.4% to 61.5%)	94.1% (92.7% to 95.3%)
Mineral dust			
All	0.25 (0.19 to 0.31)	33.9% (27.3% to 41.0%)	93.3% (92.2% to 94.2%)
No COPD	0.15 (0.06 to 0.23)	25.4% (16.1% to 37.3%)	92.7% (91.1% to 94.1%)
COPD	0.32 (0.24 to 0.40)	38.7% (30.2% to 47.9%)	93.8% (92.3% to 95.0%)
Combined dust †			
All	0.40 (0.36 to 0.44)	49.4% (45.3% to 53.5%)	88.8% (87.4% to 90.1%)
No COPD	0.38 (0.31 to 0.44)	49.0% (42.8% to 55.3%)	88.2% (86.0% to 90.1%)
COPD	0.41 (0.36 to 0.47)	49.7% (44.3% to 55.1%)	89.3% (87.3% to 91.1%)
Diesel exhaust			
All	0.36 (0.31 to 0.41)	65.6% (58.8% to 71.8%)	88.1% (86.7% to 89.3%)
No COPD	0.31 (0.24 to 0.38)	65.8% (54.2% to 75.9%)	87.6% (85.6% to 89.4%)
COPD	0.41 (0.34 to 0.47)	65.5% (56.9% to 73.2%)	88.5% (86.6% to 90.1%)
Overall exposure			
All	0.51 (0.47 to 0.54)	67.6% (64.4% to 70.6%)	83.4% (81.6% to 85.1%)
No COPD	0.48 (0.43 to 0.54)	65.2% (60.1% to 70.0%)	84.0% (81.4% to 86.2%)
COPD	0.52 (0.48 to 0.57)	69.2% (65.1% to 73.1%)	82.9% (80.3% to 85.3%)

* COPD status was determined by medical records and/or spirometry data.[4]

† The COPD JEM vapour–gas category was compared with the expert-assigned irritant gases or vapour category. The COPD JEM fumes category was compared with the expert-assigned metal dust and fumes category. The COPD JEM combined dust category was compared with the expert-assigned combined dust category which included metal fumes.